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(12) # EUROPEAN PATENT APPLICATION

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(54) **Wafer transfer apparatus.**

(57) An apparatus (2) for transferring wafers of at least one carrier into at least one second carrier, comprises at least one loading station and at least one unloading station; lifting means for raising the wafers to be transferred; support means movable between the stations; wafer handling means secured to the support means and being able to take several positions for handling the wafers; the wafer handling means comprise two substantially cylindrical arms protruding from the support means (4) and comprising a shaft and, at the free end, roller means (12) with slots for holding and guiding wafers, the arms being rotatable in steps of 90 degrees along the long axis and being able to take four different positions for passing the wafers between the arms, holding a first set of wafers and passing a second set of wafers between the arms and the first set of wafers, holding the first and the second set of wafers, and holding the second set of wafers and passing the first set of wafers between the arms and the second set of wafers. The apparatus allows to vary the sequence of loading and unloading and is suitable to be implemented in the automatic wafer production. Further, the roller means are easy to manufacture.

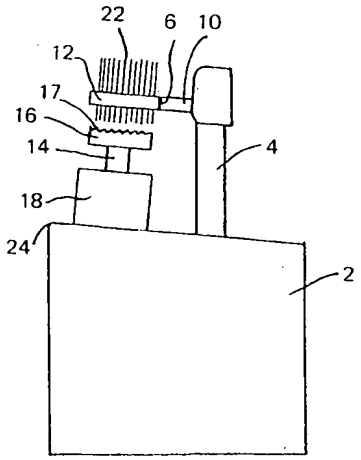

FIG. 2

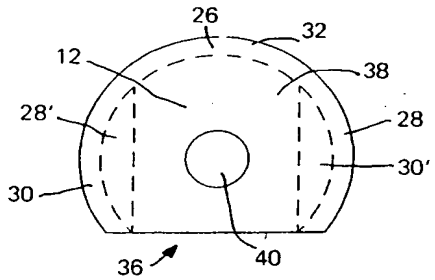

FIG. 4

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This invention relates to a semiconductor wafer transfer apparatus and, more particularly, to a transfer apparatus for moving semiconductor wafers vertically and horizontally to transfer the wafers from one location to another.

In the processing of semiconductor wafers to make semiconductor devices, the wafers are subjected to a myriad of processing steps. It is practical to perform many of these steps on a set of wafers positioned in a carrier having a plurality of spaced slots for receiving the wafers in edgewise, coaxial relation with the wafers spaced from each other. Many of these steps may be performed in a carrier made of plastic, which is relatively inexpensive and easy to work with. However, other steps must be performed at high temperatures, such as in a heat treating furnace, at temperatures that cannot be tolerated by the plastic carrier. Consequently, it is common practice to transfer the wafers from a plastic cassette to a carrier made of quartz, often referred to as a boat. Also, it is desirable to transfer the wafers from the quartz boat back to the plastic carrier.

Typically, the silicon wafers in boats are quite close to each other. A typical quartz boat will hold fifty wafers. The quartz boats hold the wafers primarily for heating purposes in ovens, and accordingly there does not need to be much space between the wafers. The spacing in plastic carriers is about half the density, or about twice as great as the spacing of the wafers in the quartz boats. There are normally about twenty-five wafers per plastic boat. The reason for the difference in spacing is that the wafers in the plastic boats will be subject to acid baths or other chemical processing, etc., and thus greater spacing is required between wafers.

The wafers can, of course, be manually transferred, but this is a delicate, tedious process, perhaps requiring the use of a tweezers, with the result that the delicate wafers are often damaged or contaminated through handling. If the damage is immediately detected, this is a serious loss simply because of the cost of the partially processed wafers. If the damage or contamination is not detected until later, in the form of an unacceptable end product or system in which the product is used, the loss is greatly amplified.

In the prior art are also disclosed wafer transfer apparatus which transfer wafers from a first carrier to a second carrier. For example EP-A-0147435 discloses a wafer transfer apparatus comprising a table with two stations and with a single lifting means which transports the wafers from one station to another and deposits said wafers in the appropriate carrier. This single lifting means is cumbersome and is in use throughout the full transfer process.

The automated system lifts a set of semiconductor wafers from a slotted carrier, transfer them laterally and lowers them into a second slotted carrier. In doing this, jaws on the lifting apparatus open automatically to receive or release the wafers. With a carrier having relatively high slotted sides, such as the commonly used plastic carrier, a pusher engages the lower edge of the wafers exposed through the bottom of the carrier and pushes them upwardly sufficiently far to permit the lifter jaws to receive and lift the wafers. The apparatus is oriented at a slight angle to insure that the wafers are all arranged in precise, spaced, parallel relation so as to cooperate with slots in the lifter jaws and slots in the receiving carrier. The system has the capability to move two sets of 25 wafers to a quartz boat having 50 more-closely spaced slots, and similarly, two sets from a quartz boat may be transferred to two different plastic carriers.

A similar principle is disclosed in US-A-4 573 851.

EP-A-0163413 discloses an apparatus which transfers semiconductor wafers from and to carriers, in which the wafers are processed. The transfer apparatus includes a movable head having rotatable holder elements which hold the wafers. Wafers are moved out of and into the carriers by vertically moving lifting elements. The lifting elements move the wafers from a carrier to the rotatable holder elements, and vertical lifting elements move the wafer from the rotatable holder elements into carriers after the head has moved itself from one station to another. Typically, there are three positions and stations for the head, and vertical lifting elements are positioned at each station for moving the wafers vertically to and from the carriers which are located at each station.

All these known transfer apparatus do not allow to change the sequence of loading and unloading which is necessary for many purposes in an automated wafer production. It is therefore an object of the present invention to remedy these drawbacks and to provide an improved transfer apparatus.

The invention as claimed therefore provides an apparatus for transferring wafers of at least one carrier into at least one second carrier. The carriers can be for example a quartz carrier having fifty slots or a plastic carrier only having twenty-five slots. The apparatus further comprises at least one loading station and at least one unloading station at which the carriers are positioned for raising the wafers to be transferred by lifting means. For moving the wafers from one station to another movable support means are provided to which wafer handling means are secured. The wafer handling means are able to take several positions for handling said wafers and comprise two substantially cylindrical arms protruding from the support means

and comprising a shaft and, at the free end, roller means with slots for holding and guiding wafers. The arms being rotatable along the long axis and being able to take four different positions: For passing the wafers between said arms (a), holding a first set of wafers and passing a second set of wafers between the arms and the first set of wafers (b), holding the first and the second set of wafers (c), and holding the second set of wafers and passing the first set of wafers between the arm and the second set of wafers (d). With this apparatus it is therefore possible to unload a first carrier which wafers occupy alternatively the odd or even numbers of slots depending on whether the arms are rotated into the one or into the opposite direction. Correspondingly, the wafers of a second carrier can pass between the wafers of the first carrier and occupy the free odd or even slots, respectively. When unloading a fifty wafers carrier it also can be varied between loading at first the odd or the second number of wafers. This capability is very necessary for the automated wafer production in which this apparatus is integrated into a production line in order to provide flexibilty in handling different wafer sets. For example, several sets of wafers can be mixed with other sets or any set of wafers can be taken of the process for testing or examining purposes.

In a preferred embodiment the rotation from one position to the next position is 90 degree. This facilitates the construction of the roller means and the control of the arms.

In a further preferred embodiment of this invention the roller means have a flat surface in the first position (a) and circular circumference with slots in the other positions (b), (c), (d). The slots have the same depth in the third position, the depth of the slots in the second and fourth positions are alternately larger or smaller, and the slots in the second position are shifted with respect to the fourth position. Preferably said smaller depth second and fourth position slots having a depth equal to that of said third position slots. This configuration allows a simple and precise manufacture of the roller means.

In another embodiment the outer circular circumference of the roller means is equal to the circumference of the shaft of the arm and made of plastic material and removable from the arm.

To prevent movement of the wafers during the handling of the transfer apparatus at least the arms and the lifting means are inclined in the range of 5 to 10 degrees so that the wafers to be transferred lean against the rear sidewall of the respective slots. Preferably the inclination is 7 degrees. In this embodiment the free end of the arms is higher than the fixpoint at the support means to provide a precise spaced parallel orientation.

For a better understanding of the present invention, together with further objects and advantages, a preferred embodiment of the invention is described in the following with reference to the accompanying drawings, in which:

Fig. 1 is a front view of the wafer transfer apparatus with a filled carrier at a first station;

Fig. 2 is a side view of the wafer transfer apparatus with wafers hanging in the arms;

Fig. 3 is a top view of the roller means; and

Fig. 4 is a front view of the roller.

Figure 1 depicts a front view of the wafer transfer apparatus 2 according to the invention. The apparatus 2 comprises two arms 6, 8 fixed to support means 4 and each comprising a shaft 10 and roller means 14 at the free end 12 of the shaft 10, (Fig. 2). Figure 1 shows a first carrier 18 at a first station filled with wafers 22 which have to be transferred by the arms 6, 8 into a second carrier 20 at a second station.

The wafers 22 are raised by lifting means comprising a pusher rod 14 and a pusher element 16 at the end with slots 17 for receiving the wafers. The construction of such a pusher element is known from the above cited prior art documents EP-A-0163413 and EP-A-0147435.

Figure 2 shows a set of wafers 22 which are held by the roller means 12 at the free end of the arms 6 and 8. The pusher rod 14 has raised the wafers by moving the pusher with the pusher element through the open bottom of the carrier 18. The arms 6, 8, the table 24 on which the carriers can be placed, and the lifting means are inclined to make sure that the wafers are always held in a spaced parallel orientation in the carriers. The inclination in the preferred embodiment is 7 degrees.

After having lifted a first set of wafers from a first carrier, a second set of wafers from a second carrier is raised by the lifting means in the same manner. This can be accomplished as disclosed in the prior art by using a second station with second lifting means or at the same station after having removed the first carrier. By using a second station the support means 4 with the first set of wafers has to move to the second station for receiving the second set of wafers.

Since the wafers of the second carrier are inserted between the wafers of the first set in order to reduce the space between the wafers, it is necessary to shift the second carrier in respect to the first carrier. By using a second station with second lifting means the pusher element which needs a second set of slots shifted in respect to the first set or the pusher element has to be shifted. By using only one station at which the wafers of both carriers are raised to build a new set

of wafers having a smaller distance than in the first and second carrier, the pusher element needs a second set of slots shifted in respect to the first set of slots so that the wafers of both carriers are arranged alternately.

For accomplishing the mixture of the wafers of the two carriers the arms 6, 8 comprise the roller means 12 at the free end of the shaft 10. The roller means 12 are depicted in Figures 3 and 4. Figure 3 shows a number of slots 26 having different depths. With the odd number slots 28 the wafers of one carrier are hold by the roller means while the wafers of the other carrier can pass through the slots 30', and with the even number slots 30 the wafers of one carrier are hold by the roller means while the wafers of the other carrier can pass through the slots 28'. With the middle 32 of the slots 28, 28' and 30, 30' in the region of the center line 34 the wafers of both carriers can be hold by the roller means.

As shown in Figure 4 the roller means have a flat surface 36 which is used when the arms are in the first position. In this position the first set of wafers, independent whether the wafers are later held with the odd number slots 28 or the even number slots 30, pass between the flat surfaces of the roller means at both arms. The depth of the slots 28' and 30' corresponds to that of the flat surface, i. e. the distance between the arm 6 and arm 8 is the same in the first position and the positions where the slots 28' or 30' are used for passing wafers between the arms. When the wafers have passed the flat surface up to a predetermined position, the arms rotate 90 degrees either both in the same direction or in different directions, depending on whether the construction of the roller means is identical or mirrored, to reach a second or a fourth position. In case that the arms are rotated 90 degrees into the second position, wafers only can be hold by the odd number slots 28 and in case that the arms are rotated 90 degrees into the opposite direction, only even number slots 30 are able to hold the wafers of the first carrier. It is clear that dependent on the alignment of the first carrier in respect to the roller means, the arms had to be rotated either into the first or second direction to reach the second or fourth position. Coming from the second or fourth position the arms rotate 90 degrees into a third position after the wafers of the second carrier have passed between the roller means through the slots 28' or 30', respectively. In the third position both sets of wafers are held by the roller means.

The roller means of this embodiment are made of plastic material and can for example easily be manufactured of a piece solid material having a cylindrical shape. The roller means have a core 38 with an inner bore 40 for receiving the free end of the arm with an adapted diameter to be fixed at the arm. The outer circumference can correspond with the circumference of the shaft 10 of arm. The roller can be removable from the arm.

Transferring wafers from two twenty-five slots carriers to one fifty slots carriers is accomplished by raising the set of wafers of a first carrier by the lifting means. The wafers pass between the arms which are in the first position up to a predetermined position a little above the arms in order to allow a proper rotation, subsequently the arms rotate 90 degree into the second or fourth position, depending on which of the set of slots 28 or 30 shall be occupied, and the lifting means are lowered to place the wafers into the respective slots. Then, a second carrier is placed on the table and aligned to the respective slots in the roller means, and the lifting means raise this set of wafers to pass between the arms through the respective slots 28' or 30' to the predetermined position. After the rotation of the arms into the fourth position the lifting means are lowered so that now fifty wafers are held by the roller means in the slots 32.

With all the wafers hanging between the arms, the support means 4 move to a second station at which the wafers are inserted into a carrier having fifty slots. Principally it is also possible, to use the first station for the fifty slots carrier, but in view of a complete automated transfer process with the use of roboters this is not so economical. The wafers are raised by the same or other lifting means up to the predetermined position which allows the rotation of the arms again into the first position so that the fifty wafers can be lowered by the lifting means into the carrier placed at the second station.

The transfer from a fifty slot carrier into two twenty-five slot carrier is accomplished vice versa. With the roller means and the rotation in 90 degree steps according to the invention, the transfer apparatus can be very flexible used in the automated wafer production because of the change of the lifting sequence. Thus the wafer can be differently mixed or inserted into or removed from the process for testing purposes of detecting process faults.

Claims

1. Apparatus (2) for transferring wafers of at least one carrier into at least one second carrier, comprising at least one loading station and at least one unloading station;

   lifting means for raising the wafers (22) to be transferred;

   support means (4) movable between said stations;

wafer handling means (8, 10, 12) secured to the support means and being able to take several positions for handling said wafers;

said wafer handling means comprise two substantially cylindrical arms (8) protruding from the support means and comprising a shaft (10) and, at the free end, roller means (12) with slots (26) for holding and guiding wafers, said arms being rotatable along the long axis and being able to take four different positions for

a) passing the wafers between said arms,

b) holding a first set of wafers and passing a second set of wafers between said arms and said first set of wafers,

c) holding said first and said second set of wafers, and

d) holding said second set of wafers and passing said first set of wafers between said arms and said second set of wafers.

2. Apparatus according to claim 1, wherein the rotation from one position to the next is 90 degrees.

3. Apparatus according to claim 2, wherein said roller means have a flat surface in said first position (a) and circular circumference with slots in the other positions (b), (c), (d), said slots having the same depth in the third position, the depth of said slots in said second and fourth positions being alternately larger or smaller, said slots in said second position being shifted with respect to said fourth position.

4. Apparatus according to claim 3, wherein said smaller depth second and fourth position slots having a depth equal to that of said third position slots.

5. Apparatus according to any one of the preceding claims, wherein the outer circular circumference of said roller means being equal to the circumference of said shaft of said arm.

6. Apparatus according to any one of the preceding claims 2 to 5, wherein said roller means being of plastic material and removable from said arms.

7. Apparatus according to any one of the preceding claims, wherein at least said arms and said lifting means are inclined in the range of 5 to 10 degrees so that the wafers to be transferred lean against the rear sidewall of the respective slots.

8. Apparatus according to claim 7, wherein said inclination is 7 degrees.

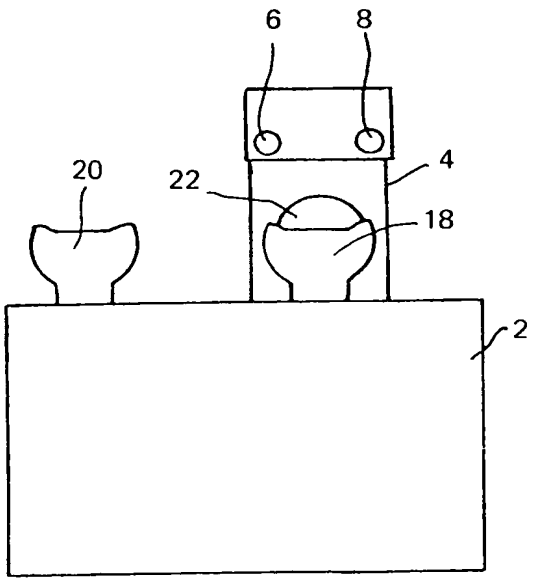

FIG. 1

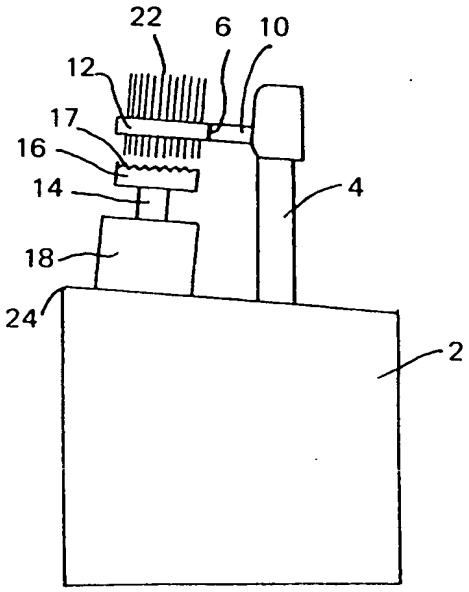

FIG. 2

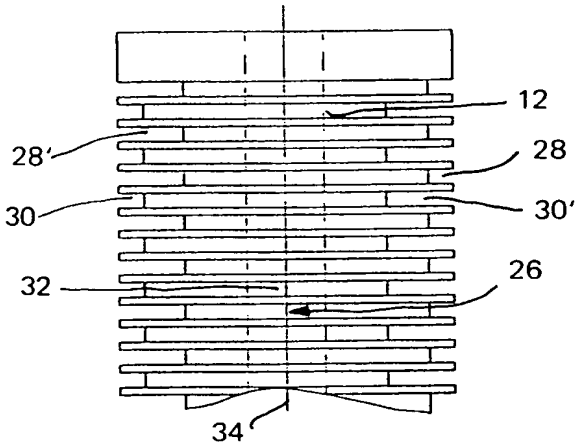

FIG. 3

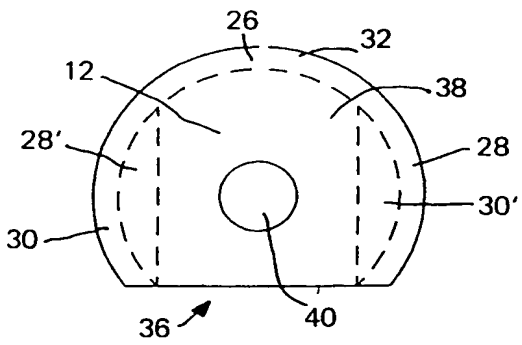

FIG. 4

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 91 10 0635

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
Y	US-A-4695217 (JOHN J. LAU) * column 2, line 58 - column 5, line 47; claims 1, 6, 7, 9-12; figures 1, 4, 5, 7A-9B *	1, 2	H01L21/00
A		3-5	

D,Y	EP-A-163413 (LESTER R. JOHNSON) * page 7, line 27 - page 18, line 22; claims 1-11; figures 1-2C, 3, 9 *	1, 2	
D,A		3, 4	

A	WO-A-8404738 (ASQ BOATS INC.) * page 6, line 20 - page 8, line 21; figures 1-3, 5 * * page 15, line 23 - page 17, line 33; figure 11 *	1, 3, 7, 8	

A	IBM TECHNICAL DISCLOSURE BULLETIN. vol. 28, no. 3, August 1985, NEW YORK US page 1350 "Odd-even wafer-carrier lifting tool" * the whole document *	1, 3, 4, 6	
	---		TECHNICAL FIELDS SEARCHED (Int. Cl.5)
D,A	US-A-4573851 (ROBERT M. BUTLER) * column 8, line 3 - column 11, line 19; figures 5, 6, 11A-12B *	1, 3, 4	H01L C30B C23C H01J B25G H05K

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	30 JULY 1991	KLOPFENSTEIN P.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
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T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
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